42nd UNECE IWG PMP MEETING

Exhaust emissions

UNITED NATIONS

Joint Research Centre
the European Commission's
in-house science service

JRC Science Hub: ***ec.europa.eu/jrc***

Joint
Research
Centre

PMP meetings in 2016

13th January 2016 (Geneva) : 38th PMP meeting

9th-10th March 2016 (Brussels) : 39th PMP meeting

27th April – 3rd May (Web/phone conference): 40th meeting

31st May (Web/phone conference)

12th-13th October (JRC-Ispra) : 41st meeting

Main open points

- Round Robin Sub-23nm
- Raw exhaust sampling
- Round Robin PNC (Particle Number Counter)
- Horizon 2020 projects

Sub-23 nm particles- Current status

- The PMP IWG has been working since June 2013 (approval date of the existing ToR) on a number of issues related to both exhaust and non-exhaust particles (i.e. particles from brake and tyre/road wear)

- Main investigations :
  - Sub-23 nm exhaust particles: Nature, number, measurement feasibility

- All the information collected are available on the UNECE website / PMP webpage

Key messages

- Sub-23 nm exhaust particles:
  - There are particles <23nm - Sometimes they are an artifact
  - Particle not counted with the current PMP method: GDIs 30-40%, motorcycles (2-s engines)up to >200%, PFIs 50-100%, DPFs 5%.
  - High emitters are still detected by PMP23nm - Thus not critical yet for current engine technologies to which the PN limit is applicable
  - Measuring particles down to 10 nm appears possible with “limited” changes to the existing methodology

New mandate / ToR

- The PMP groups has submitted to GRPE in June 2016 an updated draft version of the ToR and request a new mandate with a new specific concrete objective:
- Sub 23 nm exhaust particles:
  - Demonstrate the feasibility to measure sub23nm particles with the existing PMP methodology with appropriate modifications and assess measurement differences/uncertainties by means of a round robin (RR)
- The objectives of the proposed RR have been further discussed in the October meeting considering also new available information on new research projects
- A new document describing the RR scope and objectives has been prepared and it will be uploaded on the PMP website
- The details of the RR will be discussed during the next face-to-face meeting

Scope of the Round Robin

Development of a sub23nm (cut-off size:~ 10 nm) particle number measurement procedure based on the existing PMP methodology conveniently adapted.

Main purpose: Monitoring particle emissions of new engine/after-treatment technologies.

Assessment of the repeatability/reproducibility of the proposed particle counting methodology by means of a “round robin”.

Objectives of the Round Robin

1. Identify the modifications to the existing measurement equipment

Expected Result: The main objective is to identify the modifications to the equipment/procedure needed to measure from 10 nm and to determine whether existing systems can (or cannot) be adjusted during an annual maintenance with a relatively low cost.

2. Assess the need of a catalytic stripper (CS)

3. Evaluate sub23nm fraction of modern engines

Expected result: The fraction (percentage) of sub-23 nm particles from latest engines will be reported.

Objectives of the Round Robin

4. Evaluate measurement differences/ uncertainties. Confirm the specification of the modified systems

Expected result: The measurement uncertainty will be reported based on the RR-10 and it will be related to the technical specifications of the systems that will circulate. The need of better systems (or not) will be discussed.

5. Calibration procedures of sub23nm protocol.

6. NEW: Check measurement uncertainty of existing PMP-23nm systems.

7. NEW: Check differences between tailpipe and CVS

Expected result: The uncertainty of the 'location' will be quantified, especially for 10 nm systems.

PN system sub23nm (VPR)

Catalytic Stripper included

- VRE test to be defined (during RR and if CS necessary)
- Propane oxidation efficiency and monitoring

Calibration: Thermally stable particles >5000 p/cm3

PCRF(15nm)/PCRF(100nm)<2

- Desired also lower values: Input from instr. manufacturers

PCRF = average (30nm, 50nm, 100nm)

- It has to be understood and agreed that the around 40% of sub23nm particles are not counted (i.e. a correction of +70% of the sub23nm concentration would be needed)
- This info will not be available in the future systems as only one PNC will be counting

PN system 10nm (PNC)

Counting efficiency 10nm: >50%

- To maximize the measurement of >10 nm particles
- Values to be defined also based on existing PNCs

Counting efficiency 15nm: >90%

Calibration: Emery oil or other equivalent

- Input from CPC calibration round robin

Investigation of sub23nm protocol

One system with CS and 10nm CPC to circulate

Each lab PMP system plus a 10nm CPC (to circulate?)

One golden vehicle

Different labs will test different engine technologies

PN Counting from Raw Exhaust via Fixed Dilution

- Interest in this approach confirmed by some engine manufacturers and some instrument manufacturers
- 01 Series of amendments to Reg. 132 already includes such possibility but the procedure is not defined
- First analysis of potential benefits/issues presented during the last meetings
- Correlation with other methods (CVS and partial flow system) and advantages/disadvantages to be checked – Additional data required

Raw exhaust (tailpipe) sampling

Experimental program

- Primary dilution
- Losses
- Volatile removal efficiency
- Pressure effects
- Time alignment

JRC will wait for experimental data

Limited number of tests from PN-PEMS for HD program

Results from PN-PEMS program

PMP at CVS (APC 489, AVL) and PMP at tailpipe (Nanomet, Testo)
Correction of calibration factor 10%.
Cycles like WHVC, ISC, high load points
Exhaust flow estimated from CVS
Results from 5 vehicles, >140 cycles (34 of duration 3h each)

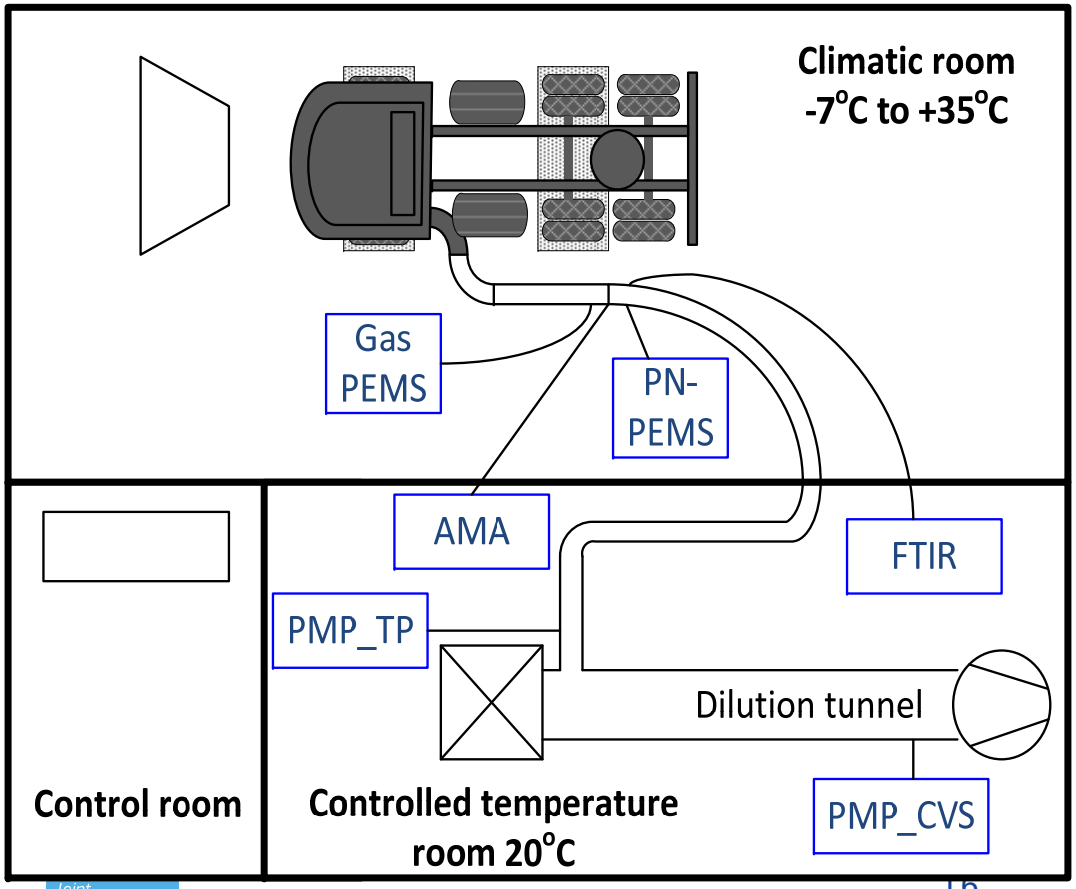
Experimental setup (JRC)

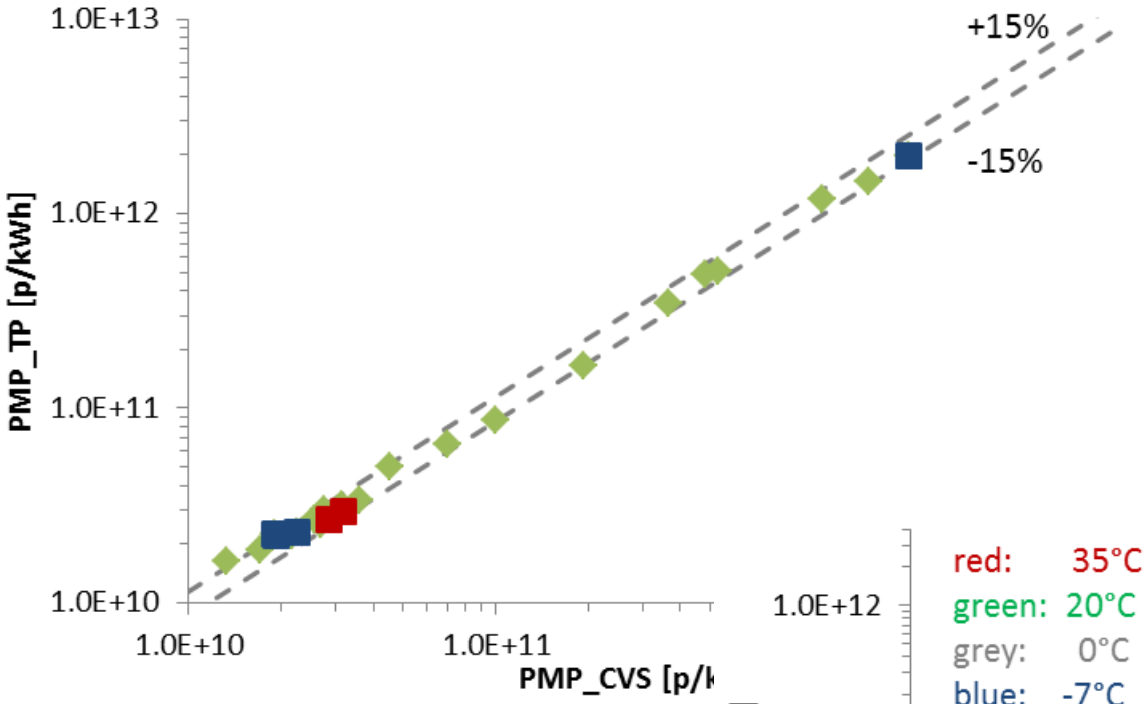
Not engine test bed

Euro VI vehicles

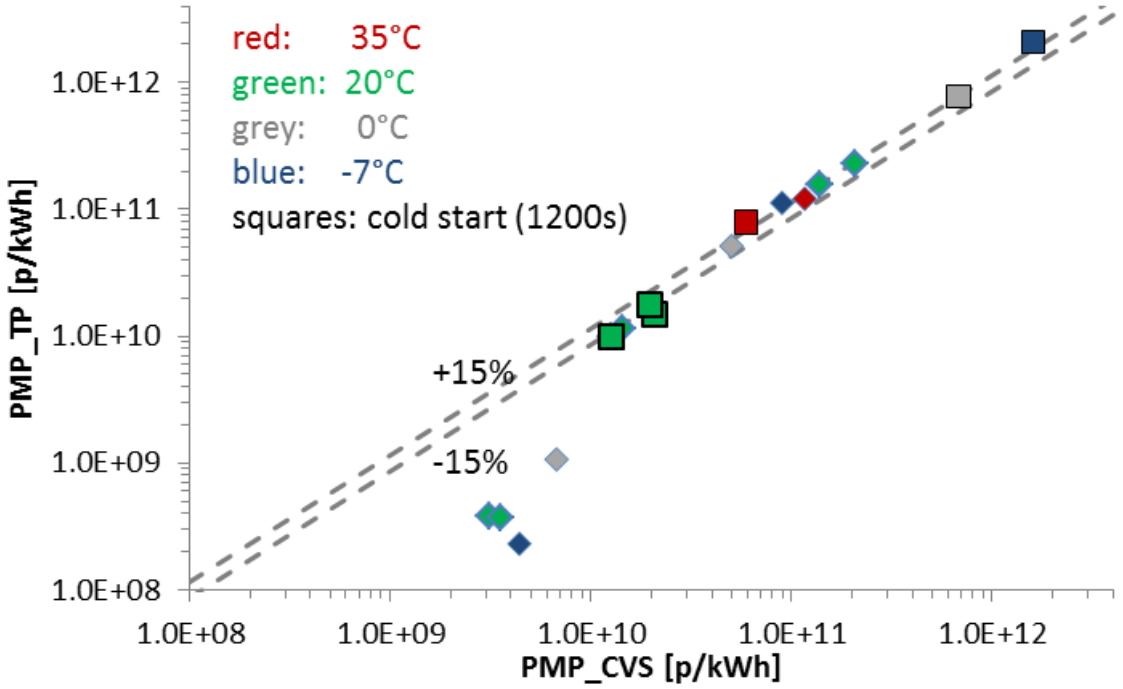
Low (thermophoretic) losses due to position of PMP_TP

EFM uncertainty <5%

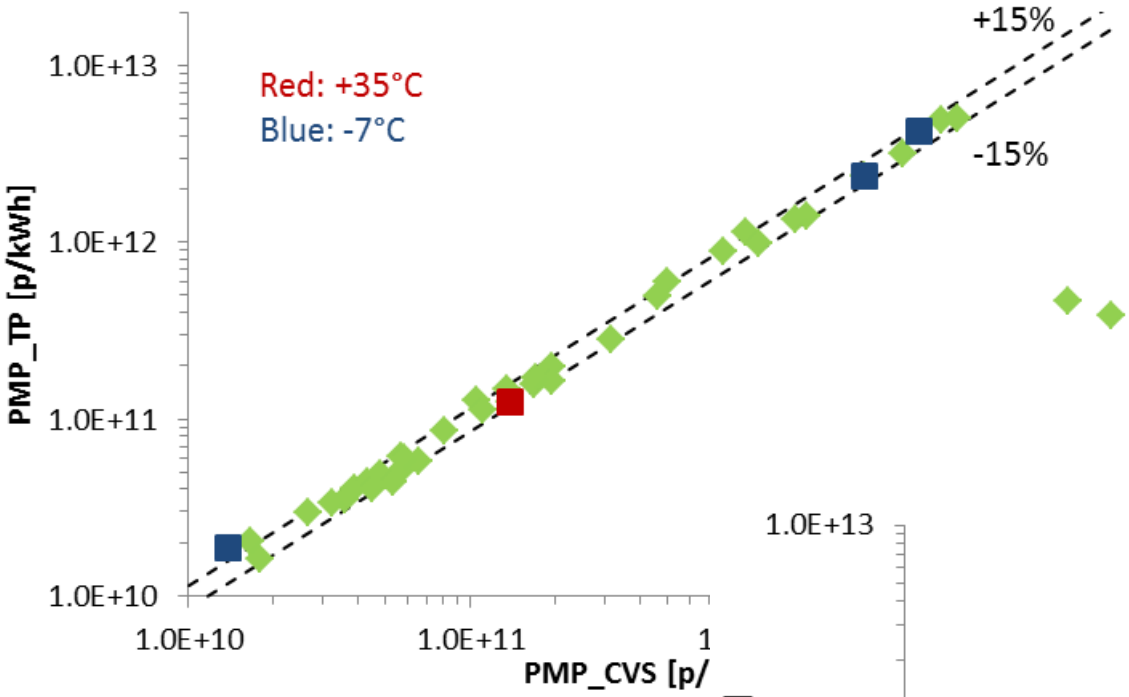


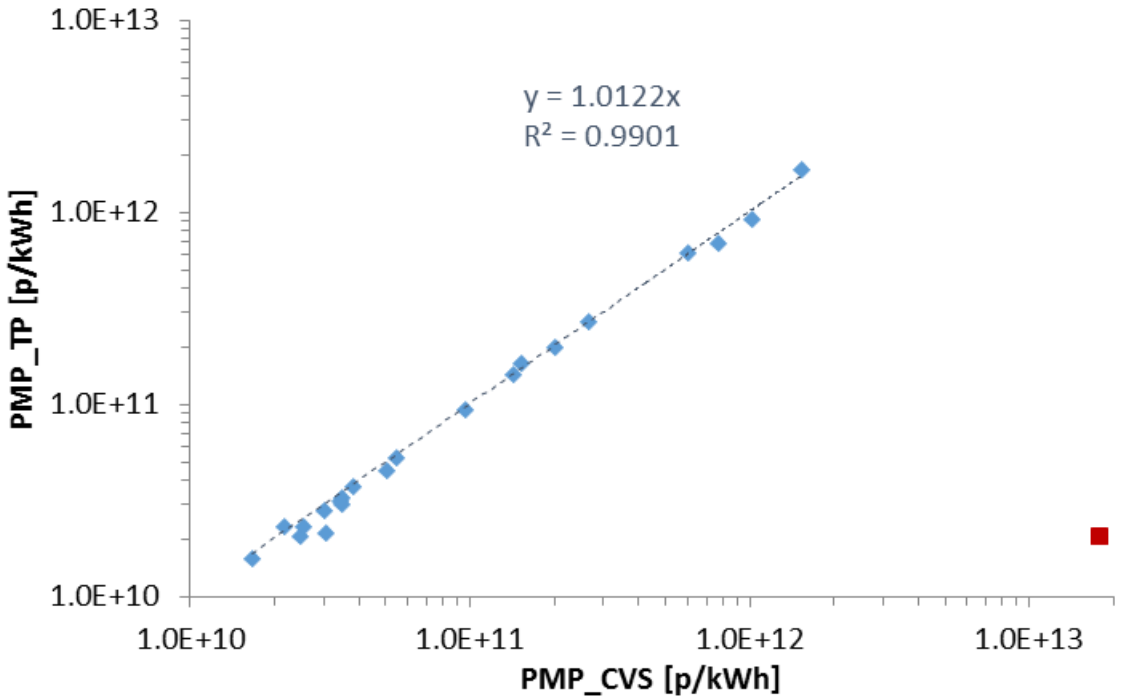

1.0E+13
1.0E+12
1.0E+11
1.0E+10
PMP_TP [p/kWh]
1.0E+10
1.0E+11
PMP_CVS [p/k
+15%
-15%

V1 & V5

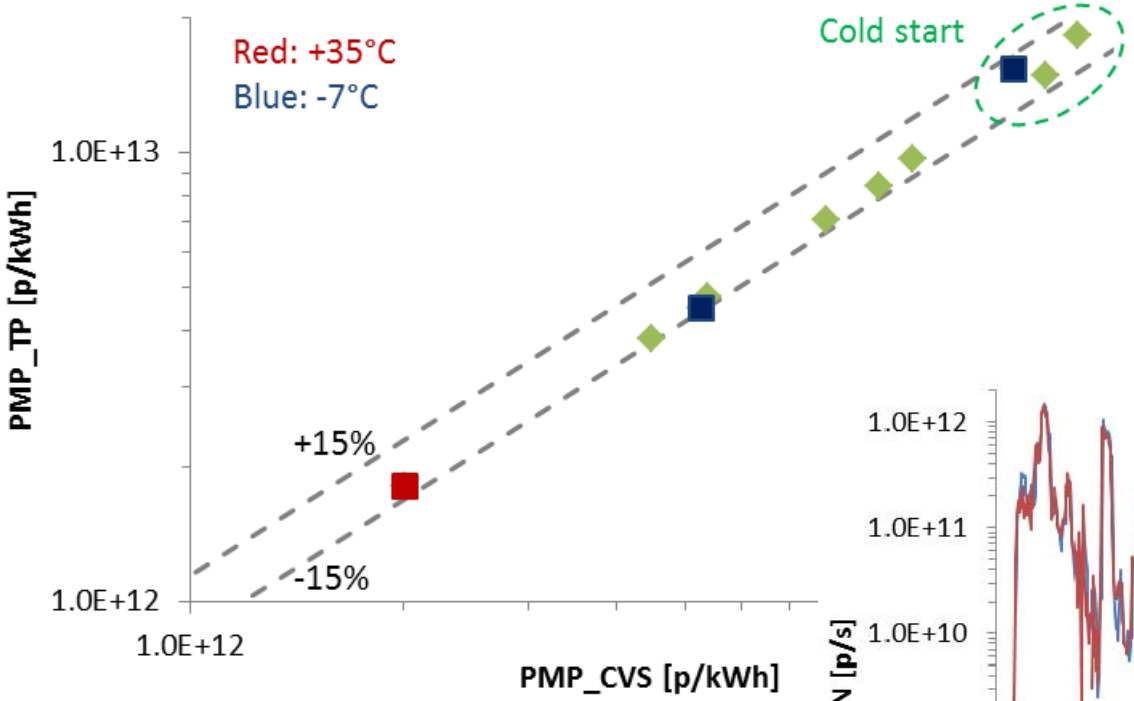

red: 35°C
green: 20°C
grey: 0°C
blue: -7°C
squares: cold start (1200s)
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
PMP_TP [p/kWh]
+15%
-15%
1.0E+08
1.0E+09
1.0E+10
1.0E+11
1.0E+12
PMP_CVS [p/kWh]

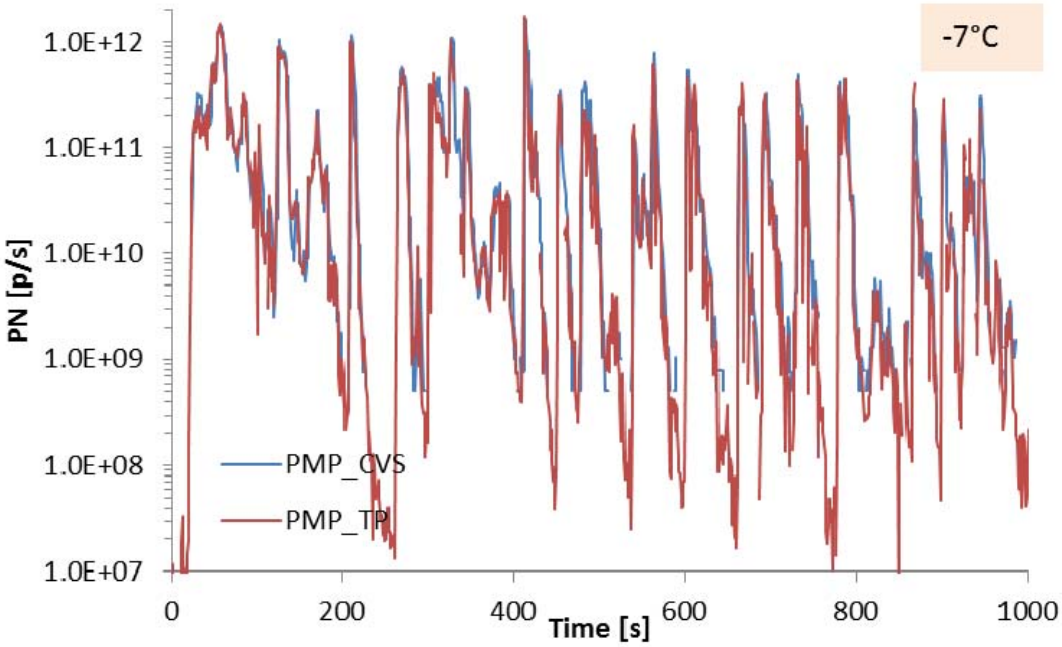
V3 & V8


+15%
-15%
Red: +35°C
Blue: -7°C
1.0E+13
1.0E+12
1.0E+11
1.0E+10
PMP_TP [p/kWh]
1.0E+10
1.0E+11
1
PMP_CVS [p/


y = 1.0122x
R² = 0.9901
1.0E+13
1.0E+12
1.0E+11
1.0E+10
PMP_TP [p/kWh]
1.0E+10
1.0E+11
1.0E+12
1.0E+13
PMP_CVS [p/kWh]

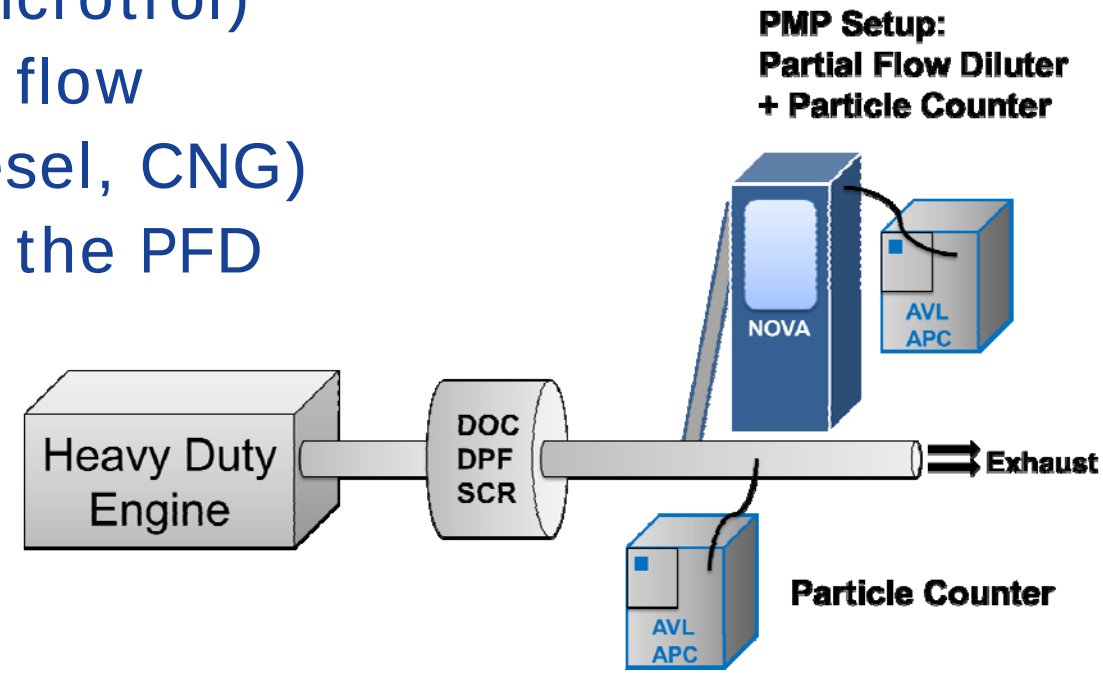
V2


Red: +35°C
Blue: -7°C
Cold start
1.0E+13
1.0E+12
1.0E+12
PMP_TP [p/kWh]
PMP_CVS [p/kWh]
+15%
-15%


-7°C
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
1.0E+07
PN [p/s]
PMP_CVS
PMP_TP
0
200
400
600
800
1000
Time [s]

Experimental setup (MAN)

APCs at tailpipe with 0.5 m heated line 150ºC
APC at PFD (Nova Microtrol)
No feeding back the flow
Euro VI engines (diesel, CNG)
Different settings at the PFD
WHTC and WHSC

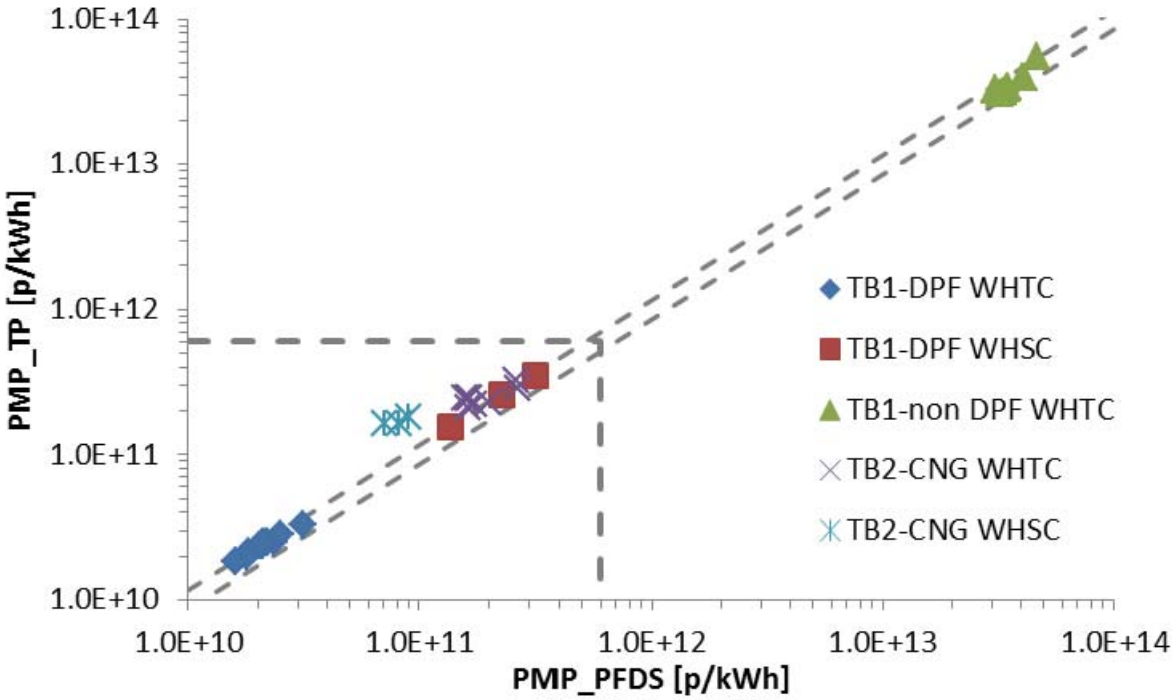


Tyroller et al. 2016, ETH poster

Results (MAN)

Differences within 20%
Higher with CNG engine

PFD setting
effect?



Tyroller et al. 2016, ETH poster

Raw exhaust sampling

Preliminary results show 20% differences

Input from others is necessary

Theoretical investigation of uncertainty

(According to recent information industry will try to generate some more data)

PNC Calibration Round Robin

- Confirm that the k factor can be included in the final counting efficiencies
- Investigate the possibility to change the calibration material
- Applicability to PN-PEMS procedures
- Investigate the possibility to calibrate at 10 nm

Calibration of PN systems

- Review of open issues (30th)
- Presentation of key areas (33rd)
- Questionnaire sent for optimizing procedures and minimizing areas of future investigation
- Summary of first replies (35th)
- Volatile Removal Efficiency (37th)
- Decision to start a PNC round robin (38th)
- Update of round robin (39th – 41st)

Targets

- Repeatability
- Reproducibility
- Harmonization (PMP – aviation – PN-PEMS)
- Expandability (shift to 10 nm)
- Based on the above, the research work should investigate:
  - 10 nm and 23 nm CPCs
  - CPCs with different steepness
  - Propanol and butanol based CPCs
  - DCs

Participants presentations during 41st PMP meeting

BMW – AVL – VW

Available on the PMP website

Final results could be available for the next face-to-face meeting

HORIZON 2020

Participants presentations

- DownToTen
- PEMS4nano
- SUREAL-23

HORIZON 2020 projects

Topic	DownToTen	PEMS4nano	SUREAL-23
Objective	Instrumentation	Fuel efficient G-DI engine	Instrumentation + vehicle testing
Size [nm]	>5-10	>10	>1
Technology	tbd	CPC	tbd
Prototype	2018	2019 Jan	2018 start
Testing	many	Single cylinder and other	Super Low Emission Vehicles
		Validation of instrument	Prototype limited availability to others
PMP link	Important	Medium	Important

European Commission

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